There are three normal types of brush assemblies:

1) fingerleaf brushes
2) leaf brushes (the claimed invention); and
3) cage brushes.

Fingerleaf brushes are metal strips which wipe or rub directly onto the commutator. These metal strips often have the contact end cut into a number of strips or "fingers." There is no carbon brush body providing the contact between the metal strip and the commutator. As such, brush wear is of prime concern and brush pressure is light to reduce wear. Due to these considerations, although the brush is very cheap, its use is limited to very low current applications and/or very short life motors. The fingers are used to reduce the contact resistance between the brush assembly and the commutator by increasing the number of contact points.

Leaf brushes also have a metal strip which provides a spring function and current path but have a carbon brush body or brush proper which provides the rubbing contact between the metal strip and the commutator. The current capacity is usually limited by the size of the carbon brush because the metal strip is capable of handling the current. However, the size of the carbon brush is kept as small as possible to avoid increasing the commutator size and thus, the overall size of the motor above that which is necessary.

Cage brushes have a carbon brush body which makes sliding contact with the commutator. The brush slides within a fixed passageway and a separate spring urges the brush into contact with the commutator. The spring or an embedded shunt connects the brushes to the power source/motor terminals.

Each general type of brush forms a separate area of technology with much research being spent in each area. Cage brushes are considered the best for high current applications and high positional stability applications.

While multiple fingers are the norm for fingerleaf brushes and multiple cages are common for large cage brush motors, cages being multiplied in both the axial and circumferential directions, it has been unknown, until now, for leaf brushes to be connected in parallel. There has up to now been no any attempt by anyone else to use leaf brushes in parallel, either axially or circumferentially.

Contrary to the Examiner's contention, it would not have been obvious to do this in light of the cited fingerleaf brushes and cage brushes. It has not been done, because it is generally

considered that providing two leaf brushes in parallel would not give any advantage over using a single large brush. If anything, a single large brush has a cost advantage, as a single bigger brush assembly is cheaper than a double brush assembly in both material cost and assembly cost. If more current-carrying capacity is required, one would simply use a bigger brush. To use two brushes in parallel would not be considered, because of the added cost of making a bigger motor, not just the cost of the extra brush.

However, the present inventor found that using two or more brushes in parallel, rather than simply reducing the wear by reducing the current density in the brushes, had a remarkable effect of extending the life of the brushes and motor beyond expectations. This was due to the brushes vibrating at different times. Previously, unlike with fingerleaf brushes, vibration in leaf brushes had been overcome in vibration-prone appliances simply by increasing brush pressure. However, according to the invention, even without requiring an increase in brush pressure, by making the natural resonance frequencies of the paired brush arms different, longer life could be obtained.

Therefore, far from being obvious, it was wholly unexpected that this result would be achieved with the claimed invention, when the general assumption was to use a different brush type to increase the expected life of the motor.

In view of the foregoing amendments and remarks, allowance of claims 48, 51-58, 60-67, 72, 75-79 and 93 is requested.

I hereby certify that this correspondence is being facsimile transmitted (703) 305-3432 addressed to: Asst. Commissioner for Patents, Washington, D.C. 20231, Attention Examiner K. Tamai, Group Art Unit 2102, on October 18, 1999:

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Respectfully submitted,

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